

# Claims

[c1] We claim:

1. A method of regulating landfill gas well production flow rate comprising:
  - a. installing a constant flow control wellhead assembly gas path in a section of piping between each well, or grouping of wells with a single extraction pipe, and the a well extraction vacuum source,
  - b. opening a differential pressure-regulating valve in the wellhead assembly gas path to a nominal position,
  - c. opening a manual valve in the same wellhead assembly gas path partially,
  - d. measuring the differential pressure across the differential pressure-regulating valve,
  - e. adjusting the manual valve position to set the desired differential pressure across the differential pressure-regulating valve,
  - f. measuring the differential pressure equivalent to the entire flow through the wellhead assembly,
  - g. adjusting the differential pressure-regulating valve, as needed, to maintain the desired differential pressure equivalent to the entire flow through the

wellhead assembly,

- h. measuring the gas composition at the wellhead assembly gas path on a periodic basis,
- i. re-adjusting the differential pressure-regulating valve position periodically, if needed, using the result of the gas composition measurement to determine the desired direction of adjustment,
- j. measuring the adjusted differential pressure across the differential pressure-regulating valve,
- k. adjusting the position of the manual valve to obtain the desired differential pressure across the differential pressure-regulating valve,
- l. measuring the adjusted differential pressure equivalent to the entire flow through the wellhead assembly, and
- m. adjusting the regulating valve, as needed, to maintain the desired differential pressure across the complete wellhead assembly gas path.

- [c2] 2. The method of claim 1 further comprising adjusting the manual valve position to set the differential pressure-across the regulating valve within a range of 1 to 4 inches WC.
- [c3] 3. A landfill gas well extraction control system comprising:
  - a. means for opening a differential pressure regulat-

ing valve in a complete wellhead assembly gas path to a nominal position,

- b. means for opening a second valve in the gas path,
- c. means for measuring the differential pressure across the differential pressure regulating valve,
- d. means for setting the second valve position to obtain the desired differential pressure across the differential pressure-regulating valve,
- e. means for measuring the differential pressure equivalent to the entire flow through the wellhead assembly,
- f. means for maintaining the entire flow through the wellhead assembly at a constant value,
- g. means for obtaining a sample for measuring the gas composition of each landfill gas well on a periodic basis, and
- h. means for adjusting, if needed, the differential pressure equivalent to the entire flow through the wellhead assembly.

[c4] 4. A multiplicity of constant flow wellhead assemblies controlling flow through piping for a multiplicity of landfill gas extraction wells that use a common extraction vacuum source, each constant flow wellhead assembly comprising:

- a. a differential pressure-regulating valve,

- b. a second valve connected to the regulating valve by piping,
- c. a piping connection to the vacuum source,
- d. a multiplicity of pressure taps arranged such that the taps measure the differential pressure across the differential pressure-regulating valve and measure the differential pressure equivalent to the entire flow through the wellhead assembly,
- e. a control circuit providing display capability of the differential pressure between the pressure taps equivalent to the entire flow through the wellhead assembly, and display capability of the differential pressure between the pressure taps equivalent to the differential pressure across the differential pressure-regulating valve, and which positions the differential pressure-regulating valve to maintain a desired flow through the wellhead assembly, and
- f. a sample collection port located in the piping such that a sample of the well gas may be obtained.

[c5] 5. The wellhead assembly of claim 4 further comprising the differential pressure-regulating valve is configured such that at any initial valve position an increment of valve flap motion provides the same change in differential pressure.

- [c6] 6. The wellhead assembly of claim 5 further comprising gas stream temperature is measured upstream of the valves and is provided to the control circuit which closes the pressure-regulating valve in the event of high temperature.
- [c7] 7. The wellhead assembly of claim 6 further comprising the differential pressure equivalent to the entire flow through the wellhead assembly is the difference between the pressure upstream of a flow measurement device and the pressure downstream of a flow measurement device.
- [c8] 8. The wellhead assembly of claim 6 further comprising the differential pressure equivalent to the entire flow through the wellhead assembly is the difference between the pressure upstream of both the pressure-regulating valve and second valve and the pressure downstream of both the pressure-regulating valve and second valve.
- [c9] 9. The wellhead assembly of claim 6 further comprising a battery power supply for the control circuit.
- [c10] 10. A constant flow control wellhead assembly for a landfill gas well extraction system comprising:
  - a. a manually controlled valve providing an open position, a closed position, and a multiplicity of par-

tially open valve positions,

- b. a pressure-regulating valve,
- c. a multiplicity of pressure measurement taps in the piping arranged such that two taps may be used to measure the differential pressure across the pressure-regulating valve and such that two taps may be used to measure the differential pressure equivalent to the entire flow through the wellhead assembly,
- d. a sample tap such that a sample of the landfill gas passing through the wellhead assembly may be obtained, and
- e. a control circuit arranged such that the differential pressure across the pressure-regulating valve may be displayed to set the desired position of the manually controlled valve, and the differential pressure equivalent to the entire flow through the wellhead assembly may be displayed such that it may be used as a control parameter for the pressure-regulating valve.

[c11] 11. The wellhead assembly of claim 10 further comprising the pressure-regulating valve includes a flow area and a movable flap, the flow area is configured such that at any initial valve position an increment of valve flap motion provides a linear relationship with the change in differential pressure.

- [c12] 12. The wellhead assembly of claim 11 further comprising the pressure-regulating valve flap having a range of movement from a closed position, that entirely covers the flow area, to a fully open position, that completely uncovers the flow area, and the flap has a straight lower edge, the location of the straight lower edge in the flow area defining the size of the open flow area through which fluid may traverse the valve, and the flow area having an upstream side and a downstream side, and the flow area is configured to provide the linear relationship between the difference in fluid pressure on the upstream side and on the downstream side and the position of the flap between the open and closed positions.
- [c13] 13. The wellhead assembly of claim 12 further comprising the pressure-regulating valve is positioned by a signal generated by the control circuit.
- [c14] 14. The wellhead assembly of claim 13 further comprising gas stream temperature is measured upstream of the pressure-regulating valve and used in the electronic control circuit to close the pressure-regulating valve in the event of high temperature.
- [c15] 15. The wellhead assembly of claim 14 further comprising a battery power supply for the control circuit.

- [c16] 16. The wellhead assembly of claim 15 further comprising the differential pressure-regulating valve is directly connected to the vacuum source and the manually controlled valve is upstream of the pressure-regulating valve.
- [c17] 17. The wellhead assembly of claim 16 further comprising the differential pressure equivalent to the entire flow through the wellhead assembly is the difference between the pressure upstream of a flow measurement device and the pressure downstream of a flow measurement device.
- [c18] 18. The wellhead assembly of claim 17 further comprising the differential pressure equivalent to the entire flow through the wellhead assembly is the difference between the pressure upstream of both the manually controlled valve and pressure-regulating valve and the pressure downstream of both the manually controlled valve and pressure-regulating valve.
- [c19] 19. A linear flow differential pressure-regulating valve comprising:
  - a. a body,
  - b. a bonnet,
  - c. the body and bonnet containing a flow area and a

movable flap arranged with a range of movement from a closed position, such that it entirely covers the flow area, to a fully open position, such that it uncovers the flow area;

- d. means for moving the flap;
- e. the flow area with an upstream side and a downstream side and an opening configured whereby the location of the flap in the flow area defines the area of the flow area opening through which fluid may traverse the valve; and
- f. the flow area opening is configured such that a linear relationship exists during conditions of flow through the valve between the difference in fluid pressure between the flow area upstream side and downstream side and the position of the flap between the open and closed positions.

[c20] 20. The linear flow differential pressure-regulating valve of claim 19 further comprising the flap having an upper end and a lower end, the lower end configured with a straight lower end, and the flow area opening has an upper end and a lower end and two curved sides, the upper end and lower end differing in width such that the sides curve to define the flow opening and such that movement of the flap changes the flow through the valve proportional to the distance the flap moves.

